A MINIATURE, HIGH-SENSITIVITY, ELECTRON-TUNNELING ACCELEROMETER

Howard K. Rockstad, Tony K. Tang, J. K. Reynolds, T. W. Kenny*, and W. J. Kaiser**

Jet Propulsion Laboratory, Center for Space Microelectronics Technology, California Institute of Technology, Pasadena, CA 91109-8099 (USA), Mail Stop 302-231, Phone 818-354-0661, FAX 818-393-4540.

Thomas B. Gabrielson

NAWC Aircraft Division, Code 5044, P. O. Box 5152, War-rninster, PA 18974-0591 (USA), FAX 215-441-2490.

*Now at Department of Mechanical Engineering, Stanford University, Stanford, CA 94305.
**Now at University of California at Los Angeles and Jet Propulsion Laboratory jointly.

Prototype low-noise accelerometers have been fabricated with electron-tunneling transducers. This prototype uses a dual cantilever design as previously described, [1] consisting of a softly suspended proof mass and a stiffer cantilever which is controlled to follow the motion of the proof mass by a feedback circuit. By measuring the tunneling current between an electrode on the proof mass and the feedback-controlled monitor electrode, small accelerations can be detected with high responsivity. The high sensitivity of a tunnel transducer to small displacements is essential for the attainment of a low-noise miniature accelerometer with proof mass suspension resonant frequency of 50 to 100 Hz A prototype has been operating in the laboratory for 14 months. A prototype with dimensions of 1.2 cm x 1.3 cm x 0.1 cm was designed for underwater acoustic measurement from a few Hertz to 1 kHz. Between 30 and 300 Hz, the measured acceleration noise is 10-7 g per root Hz (10-6 m/s^2 per root Hz) or less, as illustrated in Fig. 1. Responsivity below the resonant frequency is approximately 15,000 V per g, where g is 9.8 m/s^2. Directivity measurements gave nulls at least 50 dB below the maximum. Responsivity was measured on an isolated vibration table ant] in a standard gradient-hydrophone calibrator. Self-noise was measured on the vibration table and in a vacuum-isolation chamber with consistent results. Directivity was measured in the gradient-hydrophone calibrator.

Detailed dynamics of the proof-mass motion were examined using a heterodyne laser interferometer that was scanned across the, surface. and s ynchronou sl y detected with respect to the excitation, permitting a dynamic video display of the motion of the proof mass surface under a variety of excitation conditions.

A two-axis prototype is packaged in an 8 cm^3 metal sphere for underwater acoustic applications; a hybrid circuit for feedback control electronics for each axis is contained within the sphere. l'he complete package is designed to be neutrally buoyant in water. A mockup of the mounting of accelerometer and hybrid circuit components in the sphere is illustrated in Fig. 2.

Measured performance of prototype accelerometers. hybrid circuitry, and packaging for underwater acoustic applications will be discussed. in addition, tunnel current I/f noise, not discussed in the previous paper,[1] will be discussed. Expected limits in performance, with self-noise dominated by l/f tunnel current noise except for a frequency band near the resonant frequency where it is dominated by thermal-molecular vibration in the proof mass,[1] will be discussed.

1. H.K. Rockstad, T.W. Kenny, J.K. Reynolds, W.J. Kaiser, and T.B. Gabrielson, *Tram.* 7th *Int. Conf. Solid-State Sensors and Actuators (Transducers '93), Yokohama,* Japan, June 7-10, 1993, pp. and *Sensors and Actuators A, 43 (1994-) 107-114.*

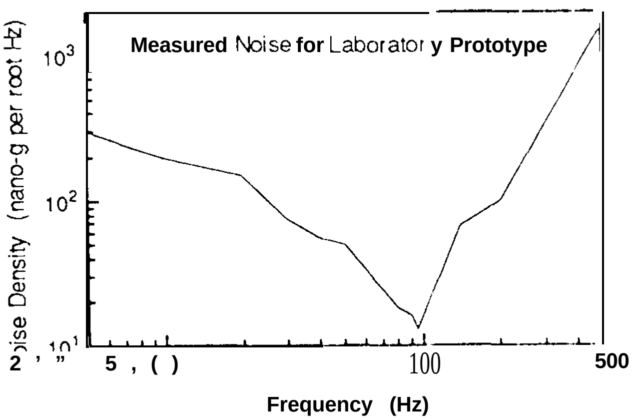

Figure 1. Measured self-noise for a prototype electron tunnel accelerometer.

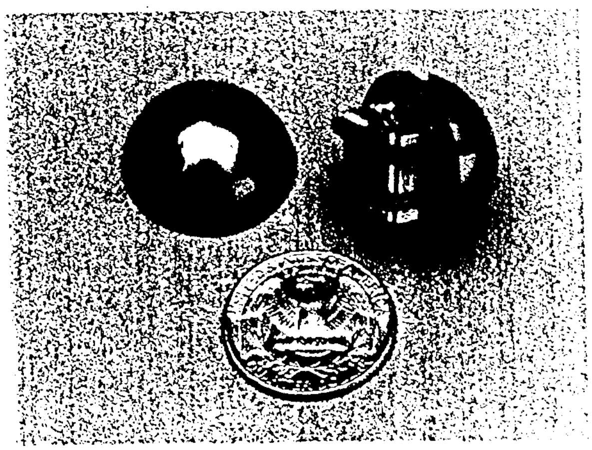

Figure 2. Mockup illustrating the mounting and packaging of accelerometer chips and circuit substrates for a two-axis hydrophone.